Claim 20 (original): The film of claim 17, wherein the shape memory alloy is selected from one of Au:Cd, Fe:Mn:Si, Cu:Zn:Al, Cu:Ni:Al and higher order alloys based thereon.

Claim 21 (new) The process of claim 5, wherein the distance between the source and the substrate is no greater than 15.2 cm.

REMARKS

The disclosure of the present invention effectively discloses the processing conditions required for producing two-way shape memory effect in thousands of alloy systems, as will be detailed in this response. The Applicant thanks the Examiner for comments in the office action mailed March 9, 2005. The Applicant respectfully traverses the Examiner's rejections. Additionally, new claim 21 has been added. Amendments to the claims have been entered to clarify the original scope of the claims, putting the claims in better condition for allowance. Entry of the amendments is respectfully requested.

In Reference to Examiner's Comment 2

Double Patenting

With respect to claims 15-16 and 18, the claims are patentably distinct from claims 9-10 of U.S. Pat. No. 6,689,486 (the "Parent Application"). A undistorted three-dimensional film is not shown in Fig. 33 nor disclosed in paragraph [0080]. Claims 9 and 10 do not claim a three-dimensional thin film. Instead, the films of claim 9 and 10 are prepared by conducting a separate step of deformation processing. Claims 9 and 10 read, as follows:

9. A microscale actuator for active flow control, comprising: a SME thin film comprised of nickel and titanium, wherein the thin film is sputter-deposited, and the thin film comprises a bubble membrane, and the thin film has a compositional gradation through at least a portion of the thickness of the thin film, and the compositional gradation is selected such that a phase change occurs above room temperature, wherein the phase change is capable of activating a two-way shape memory effect in the bubble membrane.

10. A micro scale actuator of claim 9, wherein the bubble membrane extends when heated **and flattens when cooled.**

The film is flat at a specific operating temperature. After deformation processing, the film has a three-dimensional shape; however, the memory effect returns the film to its flat condition.

Ho does not disclose a film formed as a three-dimensional actuator shape on a three-dimensional substrate. Figures 17 and 33 depict actuators that simply expand and contract to a flattened or planar shape, as described in col 11, ll. 21-26 and col. 17, ll. 4-17. The thin film of claims 9 and 10 are planar thin films formed by standard lithographic techniques, which are distorted out of the plane by a deformation processing step to form a bubble membrane actuator as is known in the art of one-way shape change materials. For example, upon heating above the transition temperature, the thin film foil elements curl and upon cooling return to a planar configuration. (Col. 17, ll. 11-17.) By contrast, a three-dimensional, removable scaffold structure or sacrificial structure is used as substrate for producing a film prior to any deformation processing step. For example, see paragraph [0039]. Additionally, as described in paragraph 0082, three-dimensional films are prepared by depositing a film of shape memory alloy on a scaffold material such as a metal, a ceramic, or a polymer material. No such description of a three-dimensional substrate is described in Ho.

<u>In Response To Examiner's Comment 5</u>

<u>Rejection Under 35 U.S.C. 112</u>

The specification is enabling, because it provides processing conditions and examples for a wide variety of shape memory alloys, based on parameters that are available in handbooks and phase diagrams, without recourse to undue experimentation. The Jardine affidavit is not inconsistent with the disclosure. Instead, the Jardine affidavit supports the non-obviousness of the invention, which shows that ranges for processing conditions may be selected based on the melting temperature of the alloy selected and the relative sensitivity and reactivity to certain,

comparatively reactive alloying elements. It was not known, prior to the present invention, that non-titanium alloys could be used to produce two-way shape memory alloys.

The specification discloses many examples for production of shape memory alloys other than Ni:Ti-based alloys in paragraphs [0079] – [0081]. The description in these three paragraphs provides sufficient disclosure for a person of ordinary skill to produce thousands of two-way shape memory alloy films with different alloying elements without undue experimentation. Specifically, the paragraphs recite processing conditions for preparing a wide variety of shape memory alloys based on gold-cadmium, iron-manganese-silicon, copper-zinc-aluminum and copper-nickel-aluminum and higher order alloys based on these alloy systems. The substrate processing temperature is disclosed as a range of temperatures based on the melting temperature of the alloy. For example, the process temperature is selected to be in a range from about one-third to two-thirds of the melting temperature of a quaternary or higher order alloy composition with the alloy melting temperatures ranging from 1,100 ° C to 1,400 ° C. Furthermore, the base pressure and inert gas pressures during processing are disclosed as being dependent on the reactivity of alloying elements and the sensitivity of the transition temperature and other properties to changes in concentration of the most reactive elements of the shape memory alloy system.

In paragraph [0079], a process is disclosed for preparing gold cadmium and higher order shape memory alloy films. The base pressure is disclosed as greater than 10^{-8} Torr, the distance between the target and substrate is disclosed as up to 6 inches, and it is disclosed that the thickness of the film may be greater than for a comparable film of nickel titanium. It is disclosed that Au:Cd may be alloyed with an additional element to form higher order shape memory alloys. A list of alloying elements includes hydrogen, copper, silver, zinc, mercury and combinations thereof. The target temperature range and the substrate temperature range is defined for these alloys. The substrate temperature range is based on a fraction of the melting temperature of each of the alloy systems. The fraction is disclosed as one-third to two-thirds of the melting temperature. Since the melting temperature is a known physical property of alloys that can be easily determined from phase diagrams, this provides a range of processing

conditions suitable for a wide variety of alloy systems. Thus, the disclosure provides a person of ordinary skill in the art a known range for producing gold-cadmium shape memory alloys and higher order alloys of gold, cadmium and one or more of hydrogen, copper, silver, zinc and mercury having two-way shape memory effect. A range of vacuum pressure is also disclosed, which is broader than for nickel-titanium alloys, because each of the elements are less reactive with common contaminants than is the titanium of Ni:Ti alloys. The specification also discloses the base pressure and details about the enclosure that make this alloy easier to produce as a two-way shape memory film.

In paragraph [0080] of the specification, an iron manganese silicon quaternary or higher order alloy is disclosed. The additional alloying elements are disclosed as hydrogen, boron, carbon, magnesium, aluminum, silicon, phosphorous, sulfur, calcium, scandium, titanium, vanadium, chromium, colombium, nickel, copper, zinc, selenium, strontium, yttrium, zirconium, niobium, molybdenum, ruthenium, rhodium, palladium, silver, cadmium, tin, antimony, tellurium, barium, lanthanum, hafnium, tantalum, tungsten, rhenium, osmium, iridium, platinum, gold, lead, bismuth, polonium, cerium, praseodymium, neodymium, samarium, europium, gadolinium, terbium, ytterbium, lutetium, thorium, protactinium, uranium and combinations thereof. Again, the processing temperature range for the substrate is selected based on fractions of the melting temperature of the alloys, which is a physical property easily determined from known phase diagrams or by way of simple experiments using sensitive, calibrated temperature measurements. A lower limit on target temperature is given, and the range of vacuum pressures during processing is disclosed. The base pressure during purging to produce two-way shape memory effect films is provided, also.

In paragraph [0081] of the specification, examples of a shape memory alloy based on ternary and higher alloys of copper-zinc-aluminum or copper-nickel-aluminum are disclosed. The additional alloying elements are disclosed as including hydrogen, boron, carbon, magnesium, aluminum, silicon, phosphorous, sulfur, calcium, scandium, titanium, vanadium, chromium, colombium, nickel, copper, zinc, selenium, strontium, yttrium, zirconium, niobium, molybdenum, ruthenium, rhodium, palladium, silver, cadmium, tin, antimony, tellurium,

barium, lanthanum, hafnium, tantalum, tungsten, rhenium, osmium, iridium, platinum, gold, lead, bismuth, polonium, cerium, praseodymium, neodymium, samarium, europium, gadolinium, terbium, ytterbium, lutetium, thorium, protactinium, and uranium. Ranges for the target temperature and the process temperature of the substrate are provided. A range of vacuum pressure during processing is disclosed. Using an inert gas to generate a plasma is also disclosed. A discussion concerning the reactivity of aluminum reveals that, although aluminum is more reactive to common contaminants than titanium, the degree of sensitivity to aluminum concentration of the transition temperatures and other material properties of shape memory alloys based on copper-nickel-aluminum and higher order alloys are substantially less than the sensitivity for the same properties based on titanium in nickel-titanium shape memory alloys. Thus, a range for the base pressure during purging of contaminants is given that is not obvious based merely on the reactivity of the aluminum. Therefore, the ternary alloys with aluminum nonetheless produce a two-way shape memory alloy that is relatively insensitive to impurities compared to nickel-titanium alloys. This is a surprising an unexpected result.

The process of claim 1 is enabled by the disclosure. Claim 1 recites a process comprising: "...introducing a source of shape memory alloy other than a Ni:Ti-based alloy into the enclosure...." A person of ordinary skill is instructed by the specification to select non-titanium alloy systems that have elements with either less reactivity than titanium or less sensitivity to changes in composition than nickel-titanium alloys have for slight changes in titanium in the examples and paragraph [0016] of the specification. The specification discloses that the relative degree of reactivity and sensitivity allows a greater range of base pressure and processing pressure compared to the process disclosed for nickel-titanium. Furthermore, the disclosure provides a reasonable range of processing temperatures for the substrate based on a fraction of the melting temperature of a specific alloy composition that a person of ordinary skill may use. The target temperature for a specific alloy system may then be determined without undue experimentation.

Thus, the disclosure effectively discloses the processing conditions needed for producing two-way shape memory alloy films for thousands of different alloys without any

significant experimentation, and for all non-titanium shape memory alloys without undue experimentation. Therefore, the specification is enabling for claim 1. As discussed previously, a process for selecting and processing such an alloy is generally described in the Summary and more specifically described in the examples. Thus, the disclosure is enabling for the claim.

The Summary and examples, paragraph [0036], specifically teach that alloys should be selected with elements having either a lower reactivity than titanium or alloy systems having less sensitivity to the composition of the reactive element than nickel-titanium has for changes in composition of titanium or both. The examples teach how to select the processing conditions for alloys based on the melting temperature of the shape memory alloy.

While it is possible that there are other alloy systems that are amenable to processing to produce a two-way shape memory effect, they were not known to the Applicant at the time of filing. "To demand that the first to disclose shall limit his claims to what he has found will work or to materials which meet the guidelines specified for 'preferred' materials in a process ... would not serve the constitutional purpose of promoting progress in the useful arts." *See In re Goffe*, 542 F.2d 564, 567, 191 USPQ 429, 431 (CCPA 1976). Thus, the disclosure of processing conditions for the thousands of non-titanium alloy systems known to the Applicant should be sufficient under the test for enablement. Specifically, the specification teaches how to practice the invention commensurate with the breadth of claims at the time that the application was filed, because undue experimentation is not needed for a person of ordinary skill in the art to prepare "a shape memory alloy having substantially no titanium" and capable of activating a "two-way shape memory effect." The thousands of examples covered by the processing ranges adequately enable a person of ordinary skill to practice the invention as claimed in claims 12-20.

<u>Claims Reciting Examples Recited in the Specification</u>

In addition, dependent claims 4 and 20, without amendment, are drawn to specific examples of alloy systems provided in the specification and should not have been rejected for enablement. Paragraphs [0079] – [0081] clearly enable claim 4, which recites "...selecting a shape memory alloy for the source from the group of shape memory alloys consisting of

Au:Cd, Fe:Mn:Si, Cu:Zn:Al, Cu:Ni:Al and higher order alloys based thereon." Likewise, claim 20, which recites "...wherein the shape memory alloy is selected from one of Au:Cd, Fe:Mn:Si, Cu:Zn:Al, Cu:Ni:Al and higher order alloys based thereon," is clearly enabled by the examples in the specification. Substantially no experimentation is required to apply the processing temperatures and pressures in the specified ranges to produce the desired two-way shape memory effect for the selected alloys Au:Cd, Fe:Mn:Si, Cu:Zn:Al, Cu:Ni:Al and higher order alloys based thereon. All of the processing conditions necessary for a person of ordinary skill to practice the invention are provided. Specifically, the compositions are listed, specific ranges of target and substrate ranges are based on the alloy compositions recited and on the melting temperature of the alloys, including the list of possible higher order alloying elements, which are available from phase diagrams or by way of a simple experiment to determine the melting point, as is known in the art. Ranges of vacuum pressures are given for the base pressure and processing pressure based on reactivity and sensitivity of the alloying elements to common contaminants.

Claims 5-8 depend from claim 4, and include all of the limitations of claim 4 and additional limitations. Claim 4 is clearly enabled by the specification; therefore, claims 5-8 should not be rejected as being non-enabled for being broader than the disclosed invention.

In Reference to Examiner's Comment 6 and 7

Rejection Under 35 U.S.C. 102

In order to anticipate a claim, a reference must disclose each and every element of a claim exactly. Claims 12-15 and 19 are not anticipated by Hill (U.S. Pat. No. 6,775,046) under 35 U.S.C. 102(e), because Hill fails to disclose each and every limitation of the claimed invention in such detail that a person of ordinary skill in the art, at the time the application was filed, would have had a reasonable expectation of success without undue experimentation.

Hill does not disclose a "a film comprising shape memory alloy having substantially no titanium wherein the phase change activates a two-way shape memory effect". The previously filed affidavit of the applicant declared that using the process as disclosed in Hill for does not produce a two-way shape memory effect for gold-copper. Furthermore, as stated in the

affidavit, a person relying on the reference would not have sufficient expectation of success in developing new two-way shape memory effect processes with new alloys without undue experimentation. For example, the different percentages of component metal, combinations of processing conditions and the infinite variety of shape memory alloys excluding Ni:Ti would present insurmountable barriers. By contrast, the disclosure of the present application details processing conditions and examples for a wide variety of shape memory alloys, using parameters that are readily available in handbooks, determined by simple heat of fusion experiments or published and phase diagrams, without recourse to undue experimentation. For example, one criteria, the substrate processing temperature range is selected based on fractions of the melting temperature of the alloys, which is a physical property easily determined from known phase diagrams or by way of simple experiments using sensitive, calibrated temperature measurements.

Hill specifically recognized that the shape memory material disclosed in the reference that is compositionally graded was obtained from the applicant, Shape Change Technologies of Thousand Oaks, California. (e.g., column 8, ll. 11-19.) The only compositionally-graded material available at the time was Ti:Ni alloy. Thus the disclosure of Hill does not disclose "...a film comprising a shape memory alloy having substantially no titanium ... wherein the phase change activates a two-way shape memory effect," as recited in claim 12. In order to anticipate a claim, a reference must disclose each and every limitation of a claim exactly and in sufficient detail that a person of ordinary skill in the art would have a reasonable expectation of success without undue experimentation. Hill fails to disclose any alloy of two-way type, except for a Ni:Ti binary alloy having a narrow range of compositions including titanium. Thus, Hill fails to disclose each and every limitation of claims 12 and 19, and claims 12 and 19 are not anticipated by Hill. Claims 13-14 incorporate all of the limitations of claim 12 and hence are not anticipated by Hill.

With regard to claim 15, claim 15 is amended to describe a "shape memory actuator, comprising a film formed on a three-dimensional sacrificial scaffold structure or a three-dimensional removable scaffold structure such that the film has a three-dimensional shape prior

to any deformation processing of the film..." such that the phase change is capable of activating a two-way shape memory effect." Claim 15 is not anticipated, because Hill fails to disclose the recited limitations exactly. In contrast, Hill discloses a flat substrate that produces a flat thin film in its undistorted state. (Col. 6, ll. 28-29 and ll. 47-50.)

In Reference to Examiner's Comments, 10-15

Rejection Under 35 U.S.C. 103

Claims 1-16 and 18-20 are non-obvious over Ho (U.S. Publ. No. 2002/0043456) in view of Hill (U.S. Pat. No. 6,775,046) and further in view of Bement (U.S. Publ. No. 2002/0114108).

In order to establish prima facie obviousness, a reference or combination of references must teach or suggest every limitation of a claimed invention. Furthermore, the teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art and not based on applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991).

There is no teaching or suggestion to make the claimed combination nor there is a reasonable expectation of success in any of the cited references. Any suggestion is based on improper hindsight based on the inventor's disclosure. The affidavit clearly sets forth the reasons that the presently claimed inventions are non-obvious over the cited references. "Obvious to try" is an improper rejection upon a showing that undue experimentation would be necessary.

In Reference to Examiner's Comment 11

Ho as previously discussed, does not teach nor suggest the use of any non-titanium alloy for preparing a shape change material of a two-way type and fails to teach or suggest films having alloys containing substantially no titanium

Also Ho fails to teach or suggest three-dimensional actuator shapes "prior to deformation processing." In each case, Figures 17 and 33 depict actuators that are based on

distorted films that flatten upon phase change to their original undistorted shape as described in paragraphs 0080 and 0100. Furthermore, dependent claims 16-18 claims specific shapes of films that are not disclosed in any of the cited references for two-way shape memory effect structures.

Ho, in paragraph 0066, describes planar substrates such as glass slides and wafers. Furthermore, paragraph 0073 states that control of the temperature of the target allows for fabrication of a two-dimensional (*not three-dimensional*) austentite-martensite structure. (Please see Figure 8B.)

In Reference to Examiner's Comment 11-15

Again, the referenced Ho Publication, *Sputter Deposition of NiTi Thin Film Exhibiting the SME at Room Temperatures, November 14-19, 1999*, does not teach or suggest the use of alloys having substantially no titanium for preparing a shape change material of a two-way type. Figure 14B shows only a two-dimensional substrate. The thin film in the figure is merely a planar thin film formed by standard lithographic techniques that is distorted out of the plane to form a bubble membrane actuator. Thus, this reference fails to disclose every limitation of the claims. Similarly, the second Ho publication, *Sputter Deposition of NiTi Thin Shape Memory Alloy Using a Heated Target*, does not teach any substantially non-titanium alloy for preparing a two-way shape memory alloy films. Also, the Ho publications fail to teach or suggest any three-dimensional *removable scaffold structures*.

In addition, Hill does not teach or suggest the use of any non-titanium alloy for preparing a shape change material of a two-way type, as previously discussed. The declaration filed previously clearly states that using the process as disclosed in Hill, does not produce a two-way shape memory effect for alloys of gold-copper. Furthermore, a person skilled in the art would not have sufficient expectation of success in developing new two-way shape memory effect processes with new alloys without undue experimentation, as evidenced by the Examiner's own understanding of the affidavit. For example, the different percentages of component metal, combinations of processing conditions and the infinite variety of shape memory alloys excluding Ni:Ti, as described in Bement, paragraph 0026, would present

insurmountable barriers. Thus, Bement teaches away from even trying to produce new two-way shape memory effect alloys.

Hill acknowledges that compositionally-graded shape memory material was obtained from Shape Change Technologies of Thousand Oaks, California owned by the Applicant in col. 8, ll. 11-19. No non-titanium alloys were provided by Shape Change Technologies, therefor Hill could not have been referencing non-titanium alloy.

Claims 2-11 and 21 are all dependent upon claim 1. Additionally, they incorporate all of the limitations of claim 1 and additional limitations; therefore, claims 2-11 are non-obvious.

Claim 2 recites a limitation to a "three-dimensional structure prior to any deformation processing of the claim." None of the cited references disclose, teach or suggest this limitation; therefore, claim 2 is neither anticipated by nor obvious over any of the cited references either alone or in combination.

Claim 11 recites the limitations of "...wherein the substrate is tubular, further comprising a step of rotationally adjusting the orientation of the substrate." None of the cited references disclose, teach or suggest these limitations; therefore, claim 11 is neither anticipated by nor obvious over any of the cited references either alone or in combination.

Claim 16 recites "an actuator...wherein the three-dimensional shape of the film comprises a fenestrated tubular element." None of the references disclose, teach or suggest an actuator having these limitations; therefore, claim 16 is neither anticipated by nor obvious over any of the cited references either alone or in combination.

Claim 17 recites "an actuator...wherein the three-dimensional shape of the film comprises a porous foam." None of the references cited disclose, teach or suggest an the recited limitations; therefore claim 17 is neither anticipated nor obvious over the cited references.

Claim 18 recites "an actuator...wherein the three-dimensional shape of the film comprises a dimpled spherical structure." None of the cited references disclose, teach or suggest the recited limitation; therefore, claim 18 is neither anticipated nor obvious over the cited references.

New Claim 21

New claim 21 has been added. Support for this claim is found in paragraph [0079].

The Applicant respectfully requests that the amendments to the claims be entered. All of the claims are now in condition for allowance.

I hereby certify that this correspondence is being facsimile transmitted to the USPTO, Examiner John J. Zimmerman, Group Art Unit 1775, (703) 872-9306 on the date indicated below, including a terminal disclaimer.

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